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An array of Wilcoxon VS205 vector sensors has been designed, fabricated and deployed at-sea in the shallow waters off the Scripps Institution of Oceanography pier during August of 2008.

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DURIP: Vector Sensor Array

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Final Report

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Abstract

An array of Wilcoxon VS205 vector sensors has been designed, fabricated and deployed at-sea in the shallow waters off the Scripps Institution of Oceanography pier during August of 2008. The system consists of 8 individually cabled vector sensor elements with sub-bottom deployment hardware, and a computer-controlled data acquisition and storage hardware housed in a pressure case along with preamplifiers and anti-aliasing filters. The acquisition system contains digital communications to interrogate and control the vector sensors. The data acquisition system consists of a Versalogic VSBC-8bu Win2000 Single Board Computer with a PC/104 USB 2.0 module, a 32-channel 16-bit National Instruments NI-USB 6259 data acquisition module, a custom built 64 to 32 channel differential amplifier/low pass filter PCB which provids signal conditioning for the vector sensor outputs, a B&B Electronics RS-232 to RS-485 converter and a Lacie 1-Terabyte USB external hard drive. The 64 to 32 channel signal conditioning PCB consists of 64 unity gain differential amplifiers which consolidate the outputs to 32 channels. These outputs are then passed through 32 individual 4-pole Sallen-Key Butterworth Low-Pass filters with a 5 kHz cutoff frequency before going into a NI A/D module. The 2^{nd} stage of the 4-pole low-pass filter circuit also provides a 15dB gain in signal. All data acquisition and control functions are implemented with Labview software from National Instruments.

Hardware and Deployment Summary

The hardware components for the array were assembled under a single fabrication. The array elements and cables were acquired directly from Wilcoxon. The data acquisition system, digital controls and sub-bottom mounting were fabricated at SIO. Sensors were deployed of the SIO pier during August, 2008. Eight vector sensors were buried to a depth of approximately 20 cm in the sediment roughly 40 m to the NW of the pier end to measure ambient noise and boat cavitation noise generated by a small Boston whaler, which passed over and around the array during the experiment.

Fabrication Costs

The total cost for the equipment, including the Wilcoxon array elements, the Impulse connectors and the data acquisition system, was $87,607. this cost was slightly higher than the planned $85,362. The total expenditure, including supplies, expenses and salaries and benefits, was $119,801.94.

Hardware Description

A. Vector Sensors

The eight-element array consists of Wilcoxon VS-205 sensors each having X,Y,Z Velocity and Hydrophone differential outputs as well as digital Heading, Pitch and Roll data. Ten sensors were purchased to provide spares, and two of these proved defective before deployment. The sensors were addressable, which enabled them to share one RS-485 communication line. Each VS-205 sensor arrived from Wilcoxon with six, 10m long, shielded twisted pair pigtails, onto which wet pluggable 12-pin connectors were molded by Impulse Enterprises.

The data acquisition system was configured to collect data from 8 sensors. The sensors were buried 20 cm beneath the seafloor using custom-made, PVC guides. (see Fig.5)

B. Data Acquisition System

The data acquisition system consisted of a Versalogic VSBC-8bu Win2000 Single Board Computer with a PC/104 USB 2.0 module, a 32-channel 16-bit National Instruments NI-USB 6259 data acquisition module, a custom built 64 to 32 channel differential amplifier/low pass filter PCB which provided signal conditioning for the vector sensor outputs, a B&B Electronics RS-232 to RS-485 converter and a Lacie 1-Terabyte USB external hard drive.

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The National Instruments A/D module acquired the analog data at 25 kHz for 10 minutes every 15 minute interval.

The initial proposed plan was to use PC Anywhere to remotely control and monitor this system from the Scripps Pier via a 10BaseT connection to the underwater Pier Node. The network connection back to the pier failed during deployment, requiring the data acquisition system to be reconfigured for autonomous switch-on and data collection. A circuit board with status LEDs was installed inside the computer housing allowing scuba divers to confirm that the system was operation and collecting data during deployment.

Power to the system was provided by the Pier Node's +12V, 100W and +24V, 100W DC/DC converters. These converters were powered from the Scripps Pier using a 1 kW Sorensen Power Supply Unit.

C. Underwater Housings

Two underwater housings with 3/8" aluminum walls and ½" acrylic covers were fabricated by the SIO machine shop. One housed the Versalogic computer, National Instruments DAQ module, signal conditioning circuit board, RS-232 to RS485 converter and LED status circuit. The other housing contained the Lacie 1TB external drive. Initially, the USB connection between the two housings consisted of a short cable with wet pluggable Impulse connectors on each end. The connectors ended up compromising the USB 2.0 signal integrity so another solution was implemented: Holes were drilled in the 2 housings and USB 2.0 pass-thru connectors were potted directly onto the cases.

The 2 housings were mounted onto an 18" x 18" aluminum plate bolted onto two 4' long aluminum pipes. Fifty lbs. of lead weights were also bolted to the bottom of the plate to provide stability on the seafloor. The whole assembly was lowered from the pier, towed to location using the MPL whaler and lowered into place using a lift bag.

D. Pier Node Description

The Pier Node is a junction box mounted about 1m off the seafloor about 40m NW off the end of Scripps Pier. It has 8 Impulse wet pluggable connectors of varying pin numbers that are accessible from inside the Associates Lab on the Scripps pier via a 60m cable that runs up the NW side of the pier. There are two DC/DC converters inside the Pier Node which provide +12V and +24V DC. These voltages are available through the 2-pin and 3-pin connectors on the Pier Node. The Ethernet connection is available through the 8-pin connector.

E. Cables and Connectors

A custom 30m power/ethernet cable was fabricated by Impulse Enterprises. One end had a wet pluggable 8-pin connector to connect to the Data Acquisition System underwater housing. The other end broke out into 3 wet pluggable connectors which mated to the +12V/+24V DC power outputs and single Ethernet connection of the Underwater Pier Node.

Deployment Diagram

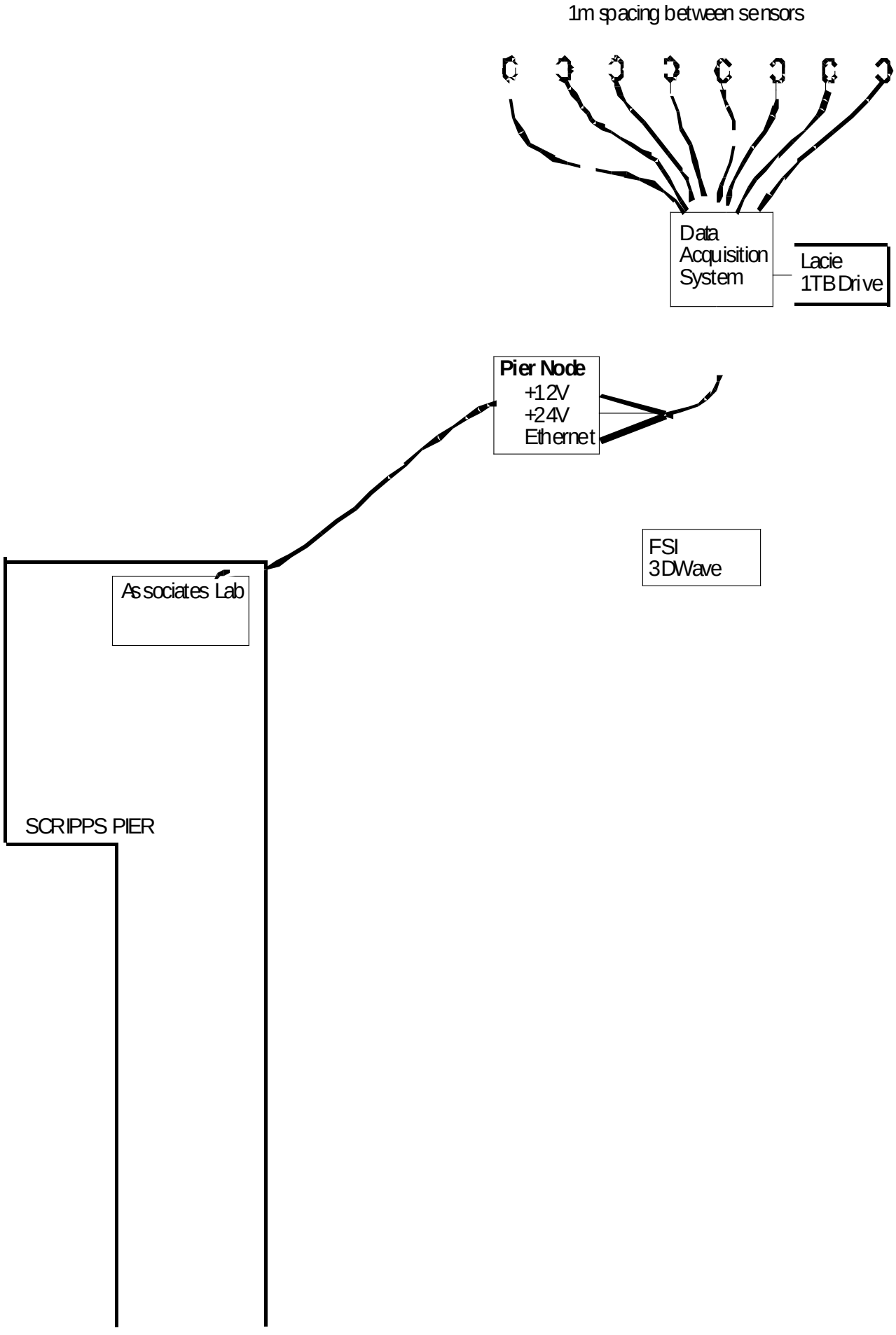

1m spacing between sensors
Data Acquisition System
Lacie 1TB Drive
Pier Node
+12V
+24V
Ethernet
FSI 3DWave
Associates Lab
SCRIPPS PIER

Figure 1. The eight VS205 sensors were deployed along a straight line parallel to the incoming waves and spaced exactly 1m apart using a marked low-stretch rope for reference.

Data Acquisition System Block Diagram

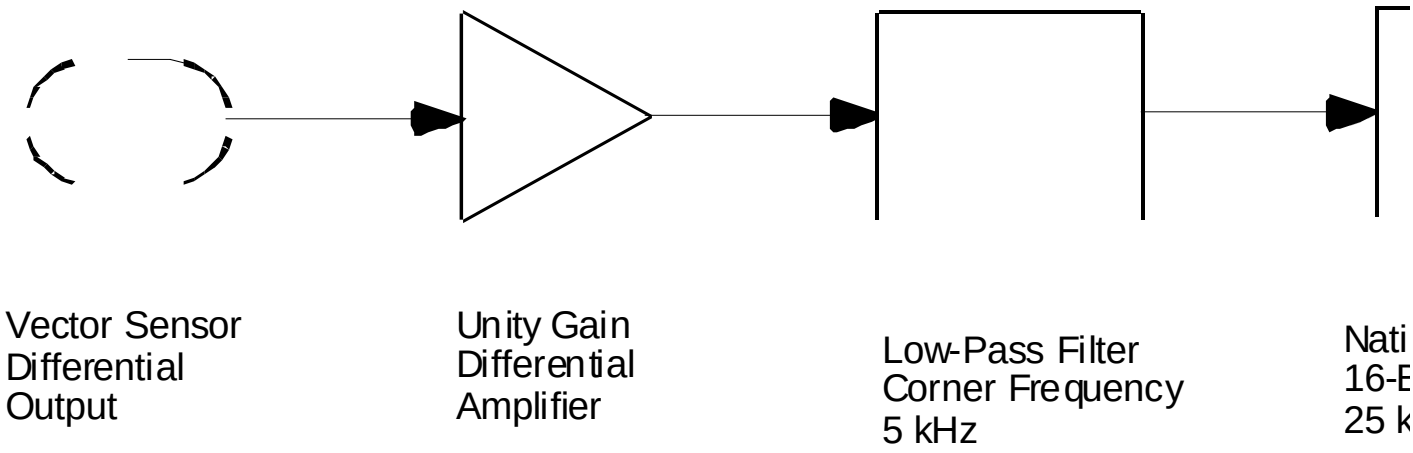


Figure 2. Flow diagram of each differential output from the vector sensor through to the A/D.

Pictures from August 06, 2008 Deployment

Figure 3. VS-205 Vector Sensor with molded 12-pin Impulse Connector.

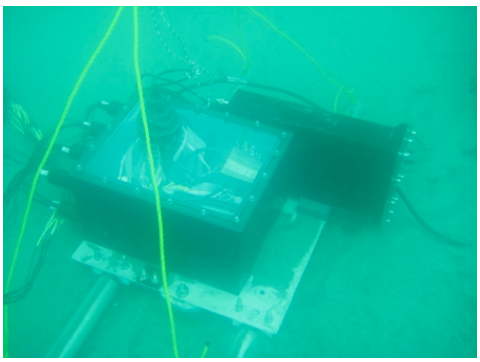
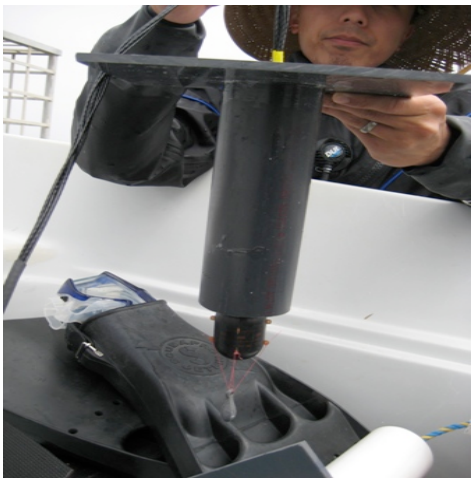


Figure 4. Data Acquisition System underwater housings mounted on frame. The yellow rope was used to lift bag the whole assembly into place.



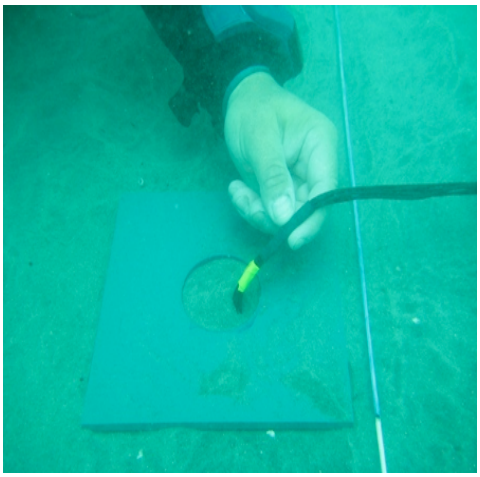


Figure 5 & 6. Photographs of the PVC burying guides pre and post-deployment. The sand was fluidized using a specially designed portable underwater jetting system. The sensor was lowered into the hole while the sand was still fluidized and held into place until the sand settled. Note the small lead weight attached to the sensor.

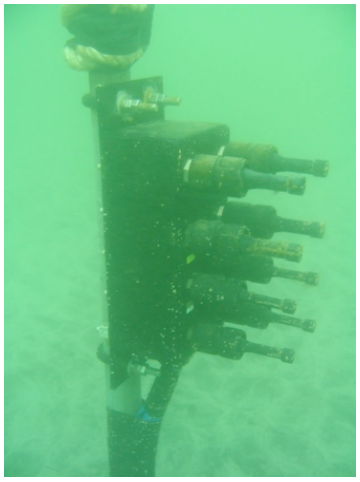


Figure 6. The underwater Pier Node used to power the vector sensor array.

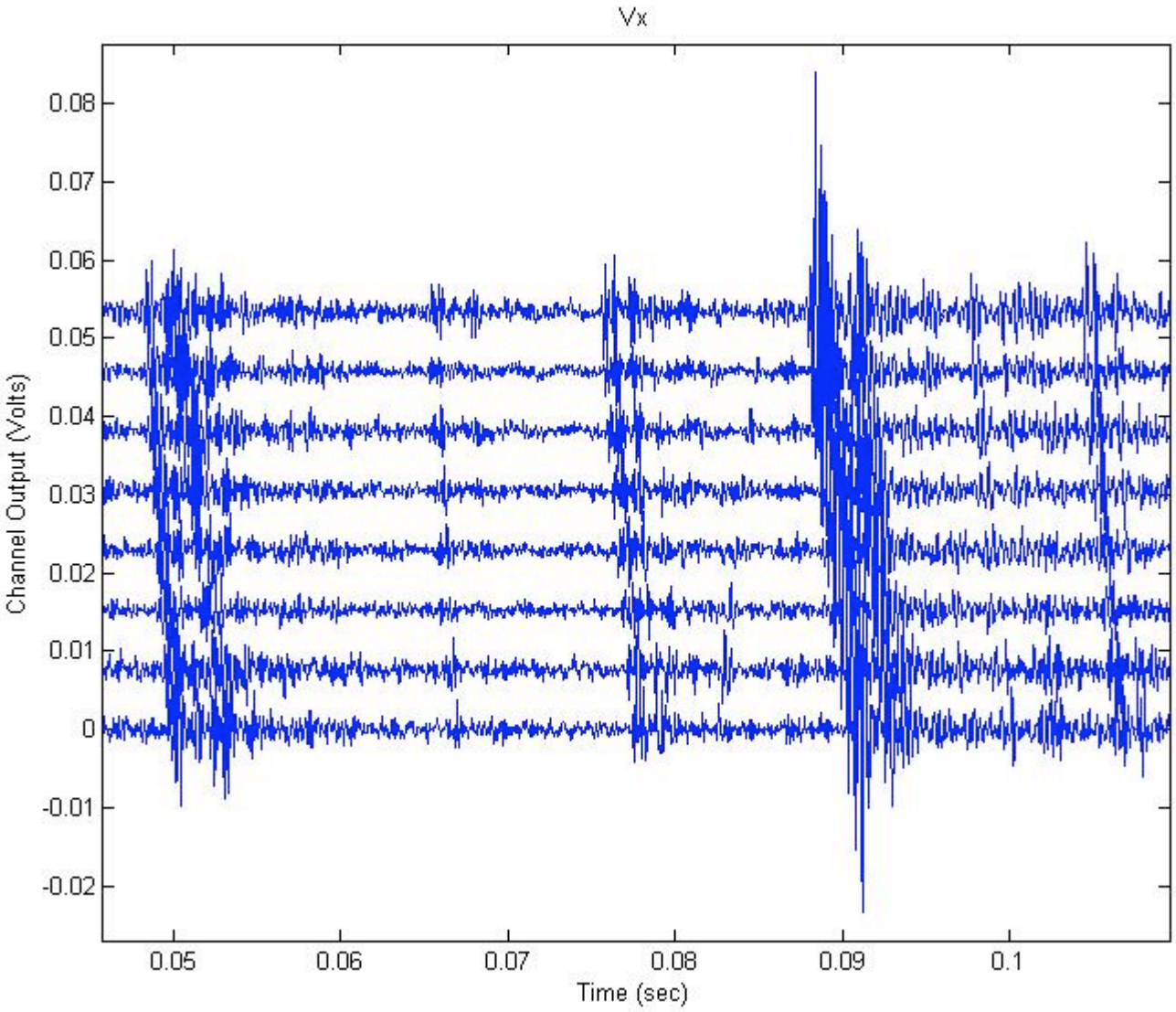


Figure 7. A time-series segment of ambient noise from the August 2008 deployment. Sensors were buried in approximately 20 cm of sediment, 40 m to the NW of the SIO pier. The energetic, impulsive arrivals are pressure pulses radiated by collapsing cavitation bubbles that are created by snapping shrimp living on the SIO pier pilings. The traces, which show the x-component of velocity, have been offset according to sensor number to create a waterfall plot.